Group Effectiveness Research Laboratory

DEPARTMENT OF PSYCHOLOGY · UNIVERSITY OF ILLINOIS · URBANA, ILL.

EFFECTS OF ORGANIZATIONAL STRUCTURE UPON CORRELATIONS BETWEEN MEMBER ABILITIES AND GROUP PRODUCTIVITY

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Communication, Cooperation, and Negotiation in Culturally Heterogeneous Groups
Project Supported by the Advanced Research Projects Agency, ARPA Order No. 454
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Principal Investigators

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Abstract

In two different studies, it was found that the contribution of member ability to group productivity was dependent upon both the ability of the member and the kind of task organization employed by the group. The first study was carried out in a military setting with forty, 4-man groups and the second study involved forty-eight, 3-man groups with undergraduate college students as subjects. When the group task required members to cooperate by coordinating their efforts, then group productivity was significantly affected by both the average ability of the group and the ability of the dullest member. Coordination was measured by the degree to which subtasks allocated to various persons were ordered by definite precedence relationship.. Collaboration was measured by the degree to which subtasks were shared by group members. When the group task required members to cooperate by collaborating, then group productivity was not significantly affected by either the average ability of the group or the ability of the dullest member.

EFFECTS OF ORGANIZATIONAL STRUCTURE UPON CORRELATIONS BETWEEN MEMBER ABILITIES AND GROUP PRODUCTIVITY[1]

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A number of reviews (Gibb, 1954; Mann, 1959; Heslin, 1964) has shown that the abilities of group members are generally related to group productivity in a positive manner. Correlations between measures of task-relevant abilities and group productivity are typically small, however. One possible reason for the smallness of these correlations is the neglect by researchers of the organization used by members in performing the group task. The organization most used in studies of small group performance is a collaborative one where group members are expected to cooperate with each other at all stages of the task activity (e.g., discussion and problem-solving tasks). Under these conditions, it has been found by some researchers that personality factors are better predictors of group productivity than task-relevant abilities (Schutz, 1958). Members with superior ability are often unable to contribute significantly because of personal conflicts and incompatibility with other members.

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Little is known about the relationship between abilities and group productivity in situations where the group is required to cooperate through task coordination rather than through collaboration. Coordination occurs when different tasks are allocated to different positions and the tasks are then ordered by definite precedence relationships. Under these conditions all members not only have an opportunity to influence the group product, but are actually required to contribute. Hence, if members of a group are allocated separate tasks of equal importance, it is likely that the group product will be proportional to their summed abilities. Furthermore, because of the definite task sequencing, it is probable that the quality of the group product would be particularly sensitive to poor performance by any one person. This form of cooperation is observed in assembly lines where shoddy performance by one worker often results in an inferior product, even though the remaining members are quite competent.

In summary, for tasks where coordination is high, group productivity should be positively related to the summed abilities of all group members and positively related to the ability of the least competent member. For tasks with high collaboration, group productivity should be less strongly related to these ability measures. Evidence to support these statements was obtained from two experiments which were concerned with the relationships between group structure and productivity. As measures of member ability were available, the effects of these abilities upon group output could be estimated.

Method

Coordination and Collaboration

In order to measure the amount of coordination or collaboration required by a given organizational structure, two cooperation indices were derived (O'Brien, 1968; Oeser & O'Brien, 1967; Witz & O'Brien, 1968). These indices can be used whenever it is possible to identify the positions and tasks in a group, the allocation relationships ordering tasks and positions, and the precedence relationships ordering tasks.

The collaboration index, C_L, is given by the formula

$$C_L = \frac{\sum_{i=1}^{i=m} \sum_{j=1}^{j=n} (p_i t_j) - n}{n\,(m-1)}$$

where $\sum_{i=1}^{i=m} \sum_{j=1}^{j=n} (p_i t_j)$ is the sum of the entries in the task allocation matrix (PT). The (ij) entry in this matrix has the value 1 if position p_i has allocated to it task t_j and the value 0 if t_j is not allocated to p_i. n = the number of subtasks and m = the number of positions.

An index of strict coordination, C_o, is given by the formula

$$C_o = \frac{\sum_{i=1}^{i=m} \sum_{j=1}^{j=m} (x_i y_j) - \sum_{i=1}^{i=m} \sum_{i=1}^{i=m} (x_i y_i)}{M(m)} + \frac{\sum_{i=1}^{i=m} \sum_{j=1}^{j=m} (u_i v_j)}{M(n)}$$

where the entries of $(x_i v_j)$ and $(x_i y_i)$ are obtained from the resultant of the following matrices:

(PT).(TT).(PT)' - (PT) ((TT).(PT)' o (PT)') - ((PT).(TT) o (PT)).(PT)

(PT)' is the transpose of (PT) and the symbol o indicates element-wise multiplication. (TT) is the precedence matrix. The (ij) entry in this matrix has the value 1 if task t_j must be preceded by task t_i and the value 0 if task t_j is not preceded by task t_i. The entries of $(u_i v_j)$ are obtained from the resultant of the following matrices

((PT)'.(PT) o (PT)'.(PT)) o (TT)- ((PT) o (PT))'.((PT) o (PT)) o (TT).

$M(m) = 1/4\ m^2$ when m is even and $M(m) = 1/4\ (m^2-1)$ whem m is odd.

$M(n) = 1/4\ n^2$ when n is even and $M(n) = 1/4\ (n^2-1)$ when n is odd.

The indices were used to calculate the collaboration and coordination values for the task organizations used by groups in the following studies.

Study I Army Study

In this study 160 Australian regular army soldiers (NCO's and privates) were assigned to forty, 4-man groups. Twenty of the groups were given the task of writing a recruiting letter and the remaining groups were required to prepare two charts showing the results of apprentice examinations at Army technical schools. Groups in each set of 20 were matched on status or rank structure and prior acquaintance.

Recruiting Letter Task

For this task, the group was asked to write a letter to Australians in the age group 17-20 years. Group members were told that the letter should explain why the Army is a worthwhile career and should encourage them to enlist in the Australian Regular Army. Instructions were given to make the letter as persuasive, fresh and original as they could. Time given to discuss and write the letter was 45 minutes. A similar task has been used by Fiedler (1967).

Chart Task

Each group was given sheets showing the scores of Army apprentices in examinations held at various apprentice schools. They were required to use this information to construct two charts showing the results for two different years. A sample chart was provided and written instructions were provided on how to calculate a percentage and construct a chart. Groups were asked to work as quickly and as accurately as they could. The time taken by different groups to complete the task varied, but average time was 40 minutes. The task involved the separate sub-tasks of a) counting the number of apprentices who passed, b) calculating percentages of passes and c) constructing the chart. Two people were required to work separately on counting the number who passed, one person to calculate percentages and the fourth person to construct the chart itself.

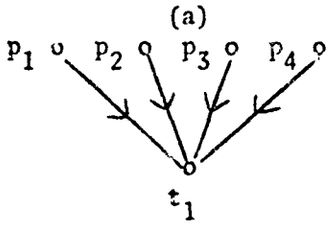
The structures of the work organizations used for these two group tasks are shown in Figure 1. In these graphs, each position and subtask are represented by points. The allocation relationships are represented by directed lines from positions to tasks, and the precedence relationships by directed lines from subtask to subtask. The collaboration and coordination values are given in Table 1.

Ability

Each soldier had been administered upon entry to the Army an Army General Classification Test (AGC). This test is a group test which includes a variety of item types including analogies, number series, verbal reasoning, patterns and circle series. This test was produced by S. Hammond and G. Bradshaw as a general classificatory test for I.Q. range 70-130. The test correlates .83 with the Otis Intermediate, .76 with the Otis Higher, and .78 with Raven's progressive matrices test.

Army Study

(a)



Letter Task:
collaboration structure

(b)

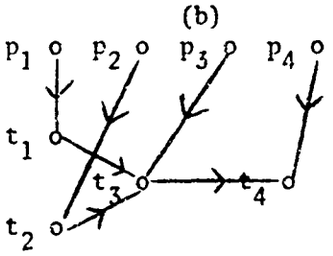
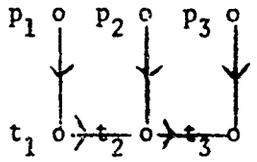


Chart Task:
coordination structure

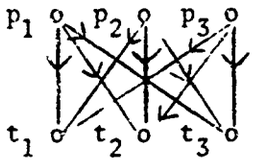
Laboratory Study

(c)



Story Task:
coordination structure

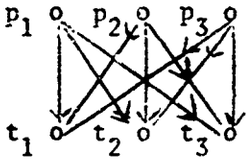
(d)

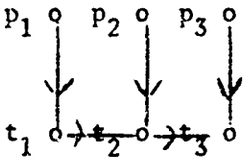


Story Task:
collaboration structure

(e)

15 minutes





45 minutes

Story Task:
collaboration-coordination structure

Figure 1. Digraphs showing the organizational structure employed by groups in the army and laboratory studies. Directed lines show the allocation relationships between positions and tasks ($p_i \rightarrow t_j$) and the precedence relationships between tasks ($t_i \rightarrow t_j$).

Table 1

Values of collaboration and coordination for tasks used in the Army and laboratory studies.

Task	Collaboration	Coordination
Letter (Army study)	1.00	0.00
Chart (Army study)	0.00	.40
Story: coordination structure (Laboratory study)	0.00	..75
Story: collaboration structure (Laboratory study)	1.00	0.00
Story: coordination-collaboration structure (Laboratory study)	.33	.55

Productivity Criteria

The letters produced were rated by six judges who were all psychologists or graduate students in psychology. None of the raters was responsible for the design of the study. Two of them were full-time army officers. Each rater was given a short training period to acquaint him with the five dimensions on which each letter was to be judged. These dimensions were:

1. Well-written, clear vs. poorly written -- sloppy, awkward
2. Understandably presented vs. confused, incomprehensible
3. Interesting vs. boring
4. Persuasive vs. unconvincing
5. Original, creative vs. trite, platitudinous

Ratings for each letter were summed over all judges using the procedure advocated by Cronbach, Rajaratnam and Gleser (1963). Inter-rater reliability was .82.

For the chart task, quality measures based on number of errors were obtained using two judges. Inter-rater reliability was .95.

Performance scores on each task were converted to 50-10 modified standard scores.

Results

Correlations between AGC scores and productivity were obtained for both sets of groups. These correlations are presented in Table 2. The correlation between the summed AGC score of a group and productivity was significant at the $p < .05$ level for the chart task, but not significant for the letter task.

Similarly, the correlation of the dullest and brightest man's AGC score with productivity was significant in the chart task groups,

Table 2

Correlation (Pearson's) of member ability score with group productivity

Correlation of group productivity with	Tasks				
	Army Study		Laboratory Study		
	Letter	Chart	Coordination	Collaboration	Coordination-Collaboration
Sum of group abilities	.13 (N=20)	.58* (N=20)	.52* (N=16)	.03 (N=16)	.52* (N=16)
Ability of dullest group member	.12 (N=20)	.56* (N=20)	.49* (N=16)	-.04 (N=16)	.56* (N=16)
Ability of brightest group member	.12 (N=20)	.48* (N=20)	.32 (N=16)	.15 (N=16)	.19 (N=16)
Ability of group leader	-.04 (N=20)	-.05 (N=20)	.41 (N=16)	.15 (N=16)	.25 (N=16)

N = number of groups used in calculating correlation.

but not in the letter task. The correlation of the leader's AGC score with productivity was small and insignificant for both task groups.

It is apparent that the contributions of group members' abilities towards productivity are dependent upon the group's task. When the task requires a high degree of collaboration, it appears that abilities of members are not related strongly to group productivity. However, when the task requires a high degree of coordination, then abilities of members are related strongly to group productivity. Although the results obtained are consistent with predictions made concerning the effect of task structure upon ability-productivity correlations, it is possible that the results could be interpreted in terms of different abilities required by the two tasks. Perhaps the abilities measured by the AGC score were relevant to the chart task only. Hence, an appropriate way to support the structural interpretation of the results would be to give a number of groups the same task or goal but vary the work organizations required to complete the task.

Study II Laboratory Study

This study was designed to study the effects of organizational structure, leadership style, and member compatibility upon small group creativity (O'Brien & Ilgen, 1968; Ilgen & O'Brien, 1968). Three kinds of interacting organizations were employed which differed in the amount of cooperation required. The goal was to construct three stories from 3 TAT pictures. Sixteen, 3-man groups were formed for each organization. These groups were matched in leadership style

(as measured by Fiedler's LPC scale) of the appointed leader and the personal compatibility of group members (as measured by Schutz's FIRO-B scale). American College of Testing (ACT) scores on English were available for each subject.

Work Organizations

Organization 1. Coordination, but no collaboration. Each member started working on one story and after 20 minutes passed his story on to the next man and received a story already started by the third man. After another 20 minutes, another exchange was made. In this manner all members worked on each story, but not at the same time.

Organization 2. Collaboration, but no coordination. All members worked together on each story for 60 minutes.

Organization 3. Collaboration and coordination. Members worked together on all stories for 15 minutes and then followed Organization 1.

Diagraphs showing the structure of these organizations are given in Figure 1.

Productivity Criteria

The stories were rated by five graduate students of English on plot originality, elaboration, plot structure, sentence structure, expressiveness, humor and suspense. Inter-rater reliability was .82 using the Spearman-Brown correction.

Results

Correlation between summed ACT English scores and productivity for summed, brightest, dullest, and leader scores are shown in Table 2. The dullest and summed measures were the only significant correlations, and these occurred only in the organizations which required coordination.

Hence, the results obtained in this study are consistent with those in the Army study in that task-relevant abilities were significantly related to group productivity only in those task organizations requiring coordination and then only for the summed abilities and the abilities of the dullest member in each group.

Discussion

The significance of these results lies in the demonstration that the contribution of member intelligence to group productivity is dependent both upon the ability of the member and on the kind of task organization employed. In tasks where there is a high degree of collaboration, it appears that members are unable to contribute significantly because the organization involves a great deal of interaction and prevents the group from organizing the best contributions in a systematic fashion. Some evidence to support this interpretation comes from observer ratings of group interaction. In the creativity study, observers recorded the number of comments made by each member and also the number of disagreements between members on the content of their stories. Collaborative organizations generated more comments and more disagreements than organizations requiring only coordination (Table 3). For the groups working with an entirely collaborative structure, their high level of interaction was associated with significantly lower productivity (O'Brien & Ilger, 1968). Organizations involving some degree of coordination had higher productivity and less interaction than collaborative organizations.

In a task where there is low collaboration, but high coordination, each member must make some contribution to the formation of the group

Table 3

Number of comments and arguments for the three task organizations in the creativity study

	Task Organization		
Median number of comments made by group members during task performance.	72	547	224
Mean number of arguments per 5-minute session	1.25	3.94	2.56

product. Under these conditions, it is not possible for a single person to make the only major contribution, but it is possible for the group to systematically organize the contributions of the group members. For a task of this kind, the principle "a chain is only as strong as its weakest link" seems appropriate. Poor work by a relatively dull person may severely limit the performance of brighter members. Only when all members have high ability for their particular task is it possible for group performance to reach a maximal level.

The results of these studies may be specific only to tasks where the group is required to combine various sources of information into one final product. Further research should be devoted to identifying organizational effects when the task requires groups to generate a large number of products from a limited number of resources (e.g., producing alternative solutions to a human relations problem). It may be that different task types require groups to have different organizations for optimal effectiveness. These results suggest, also, that the assignment of individuals to groups should be made after consideration of both their abilities, the ability of other group members, and the type of task organization. It seems to be inefficient to assign members of high ability to groups where the task allocation relationships are such that their contributions are going to be limited by the poor performance of relatively incompetent members.

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13. ABSTRACT

In two different studies, it was found that the contribution of member ability to group productivity was dependent upon both the ability of the member and the kind of task organization employed by the group. The first study was carried out in a military setting with forty, 4-man groups and the second study involved forty-eight, 3-man groups with undergraduate college students as subjects. When the group task required members to cooperate by coordinating their efforts, then group productivity was significantly affected by both the average ability of the group and the ability of the dullest member. Coordination was measured by the degree to which subtasks allocated to various persons were ordered by definite precedence relationships. Collaboration was measured by the degree to which subtasks were shared by group members. When the group task required members to cooperate by collaborating, then group productivity was not significantly affected by either the average ability of the group or the ability of the dullest member.

14. KEY WORDS

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